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QUANTIFYING THE EFFECT OF FUSELAGE CROSS-SECTIONAL SHAPE ON STRUCTURAL WEIGHT (PREPRINT)

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14. ABSTRACT
Analytical trade studies were set up and are being performed to quantify the effect of fuselage cross-sectional shape on structural weight for a cargo transport aircraft. The target vehicle design reflects various geometry, aerodynamic and inertia loads, internal pressurization, and other requirements associated with a medium-sized military transport configuration. Several elliptical cross-sections and at least one cross section containing one or more flat (LO-friendly) outer mold line segments are being evaluated. Aerodynamic loading on the fuselage is being accounted for in the trades. FEM generation and analysis includes automated structural sizing for the cargo compartment portion of the fuselage using HyperSizer. The results of this study will be used to influence decisions regarding the shape preferences for potential fuselage design candidates. The models that are created can also be used to support additional in-house trade studies to look at new structural materials and design concept candidates for transport fuselage primary structure.

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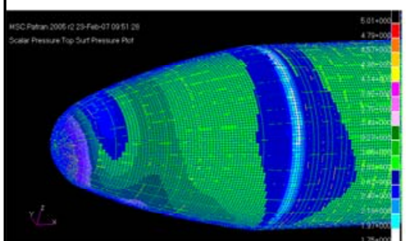
Quantifying the Effect of Fuselage Cross-Sectional Shape on Structural Weight

(Work in progress)

AIAA

The 32st AIAA Dayton-Cincinnati Aerospace Sciences Symposium



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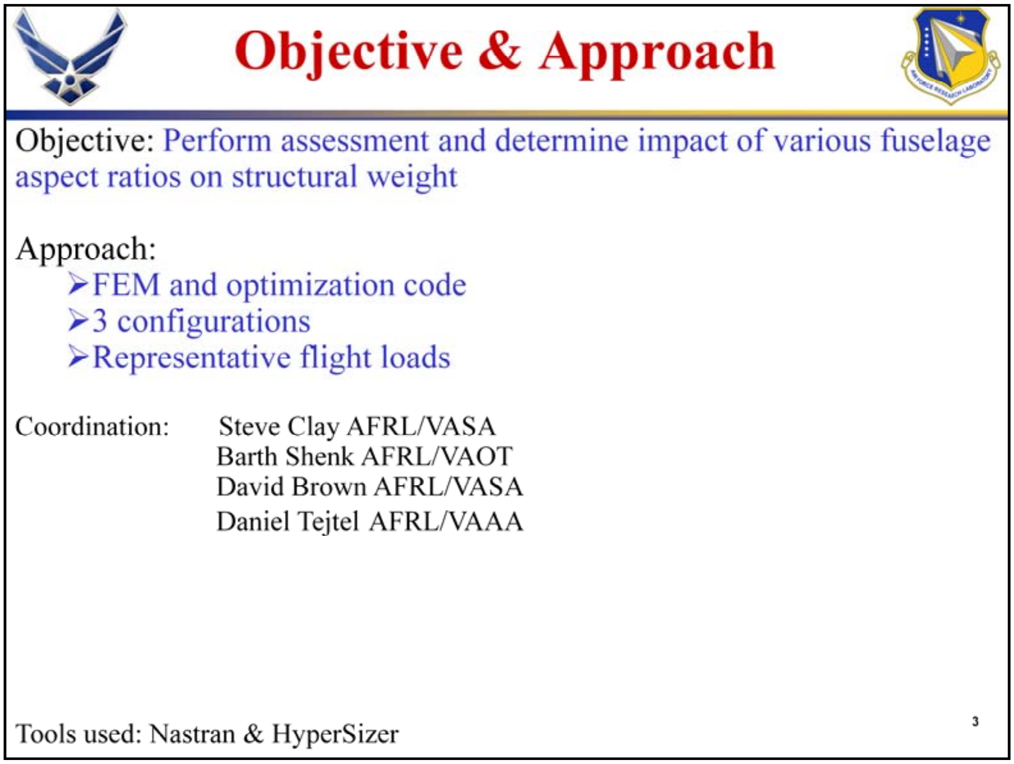
A preliminary in-house analysis was recently initiated to assess the effect of fuselage cross-sectional shape on structural weight.

Outline

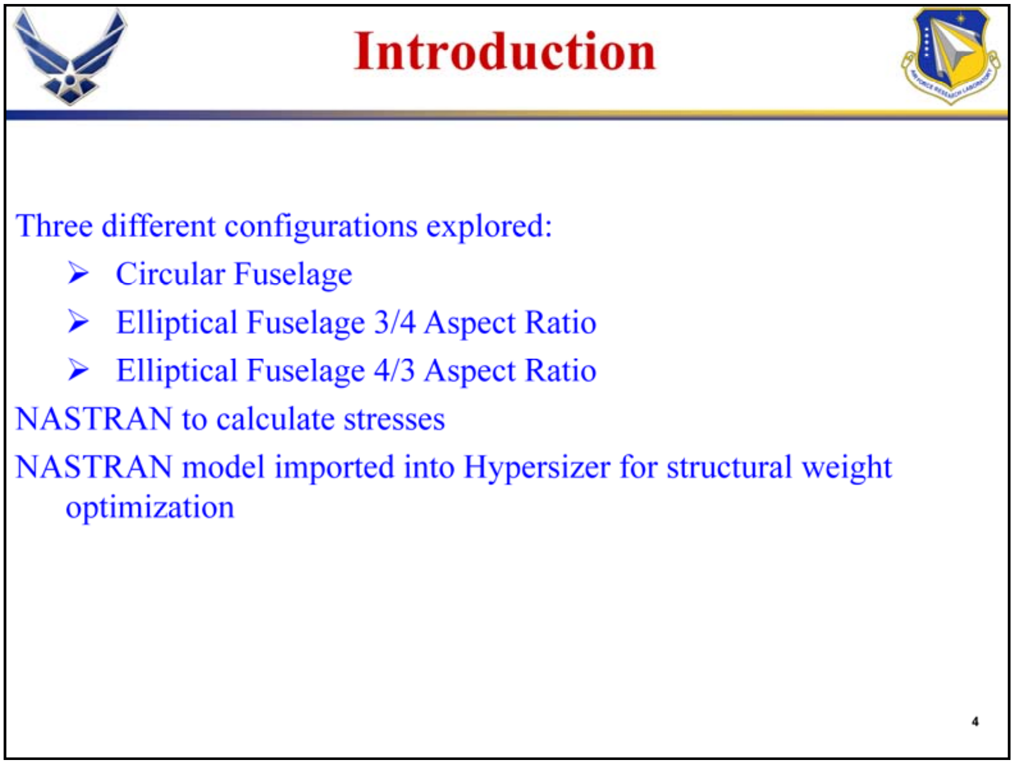
- Objective & approach
- Assumptions
- Structural description
- Fuselage structural trades
- Weight optimization
- Summary



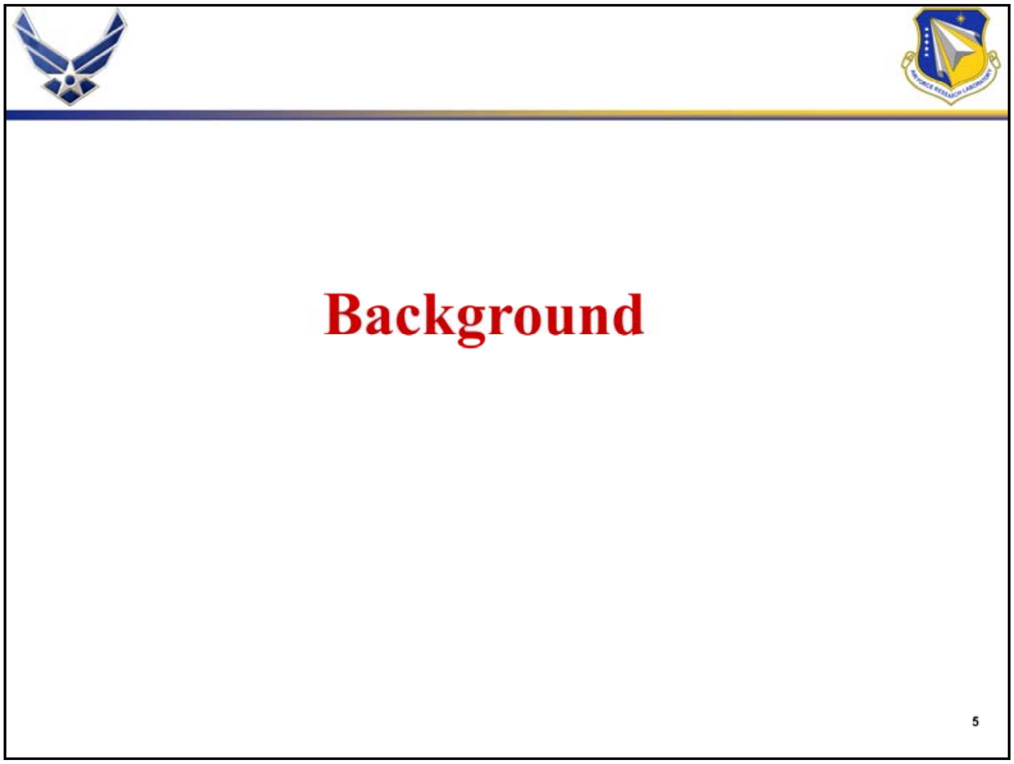
Analytical trade studies were set up and are being performed to quantify the effect of fuselage cross-sectional shape on structural weight for a cargo transport aircraft.

FEM generation and analysis includes automated structural sizing for the cargo compartment portion of the fuselage using NASTRAN and HyperSizer.

An elliptical or other non-circular fuselage provides a potentially more efficient interior shape to maximize cargo.



Preliminary design trade studies of 3 different fuselage configurations have been accomplished. MSC/NASTRAN was used to calculate stresses and Hypersizer is planed to be used for structural optimization.



As a background, an initial trade study was done on six generic fuselage configurations. This was followed by a more realistic study on three representative fuselage structures.

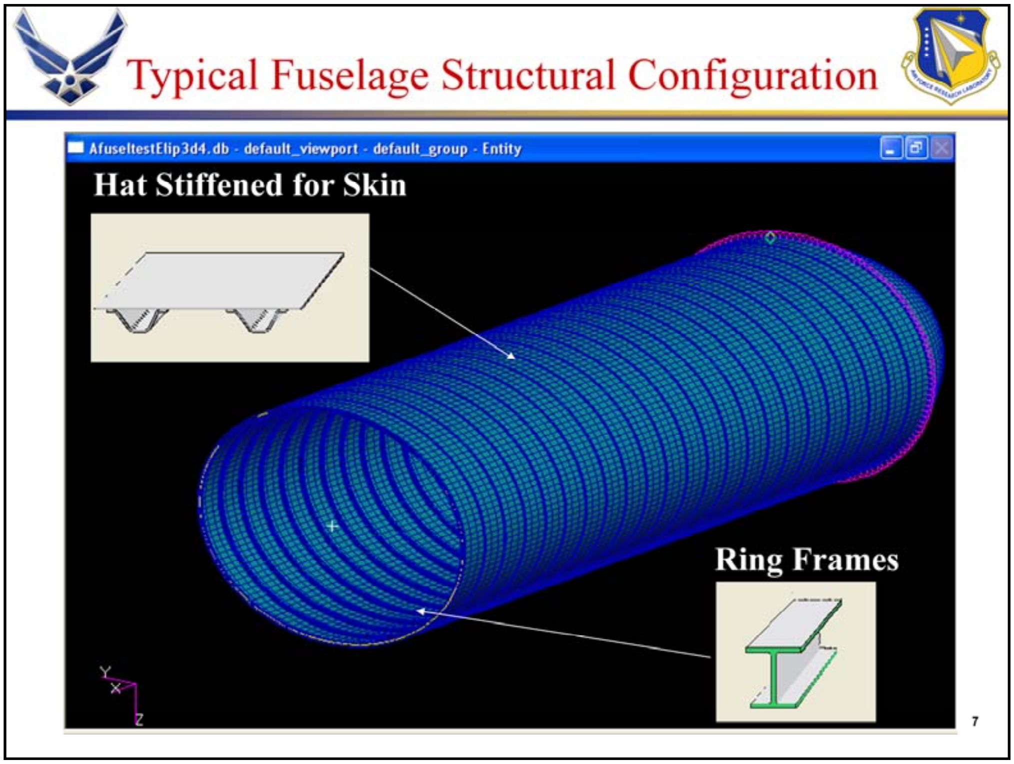
Fuselage Structural Trades

Elliptical Fuselage Configurations
(Equal Volume)

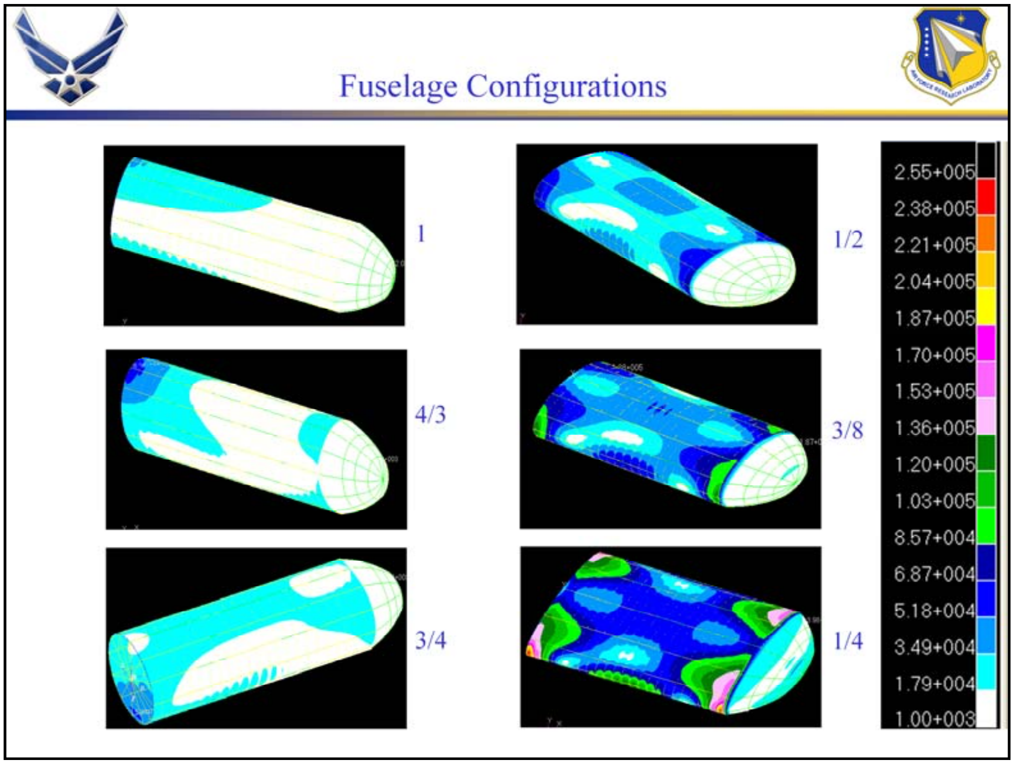
a (ft)	b (ft)	b/a
6.665	6.665	1 (circular)
5.77	7.70	4/3
7.70	5.77	3/4
9.42	4.71	1/2
10.88	4.08	3/8
13.47	3.297	1/4

Applied Loads:
- **3G Inertia**
- **Fuselage Aerodynamic Pressure Loads for 3G Pull-up Condition**
- **7 psi Pressure**

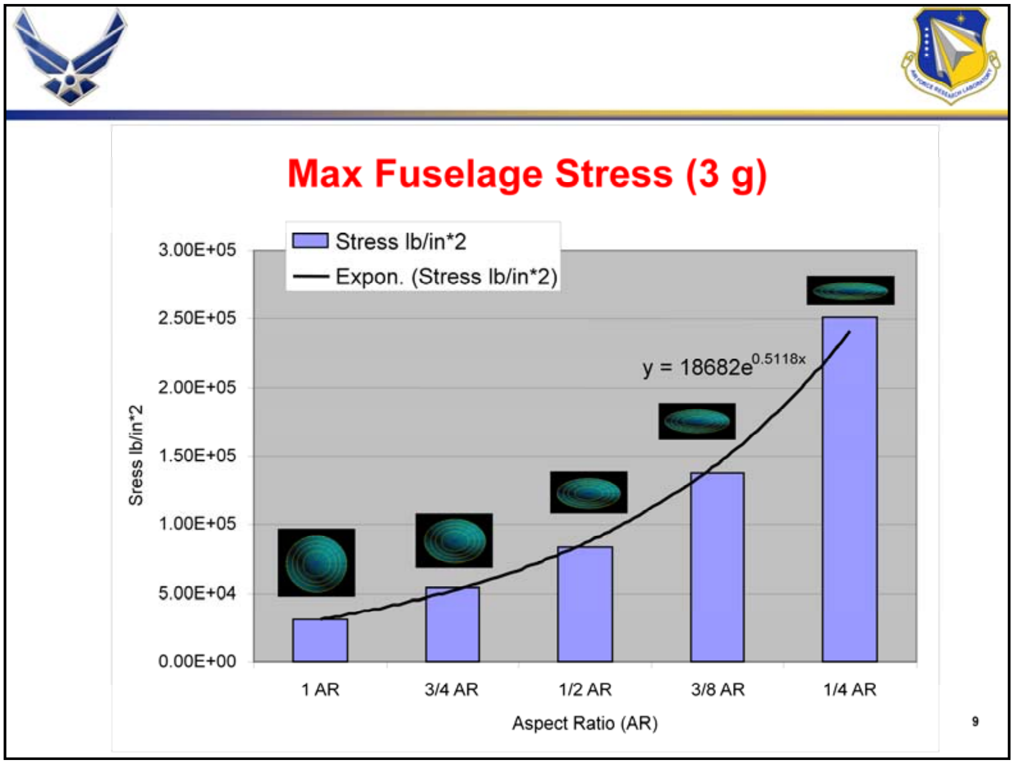
Shown are the initial six generic fuselage configurations that were studied. The baseline configuration was circular and the remaining were elliptical with different ratios of height to width. The applied loads are shown.



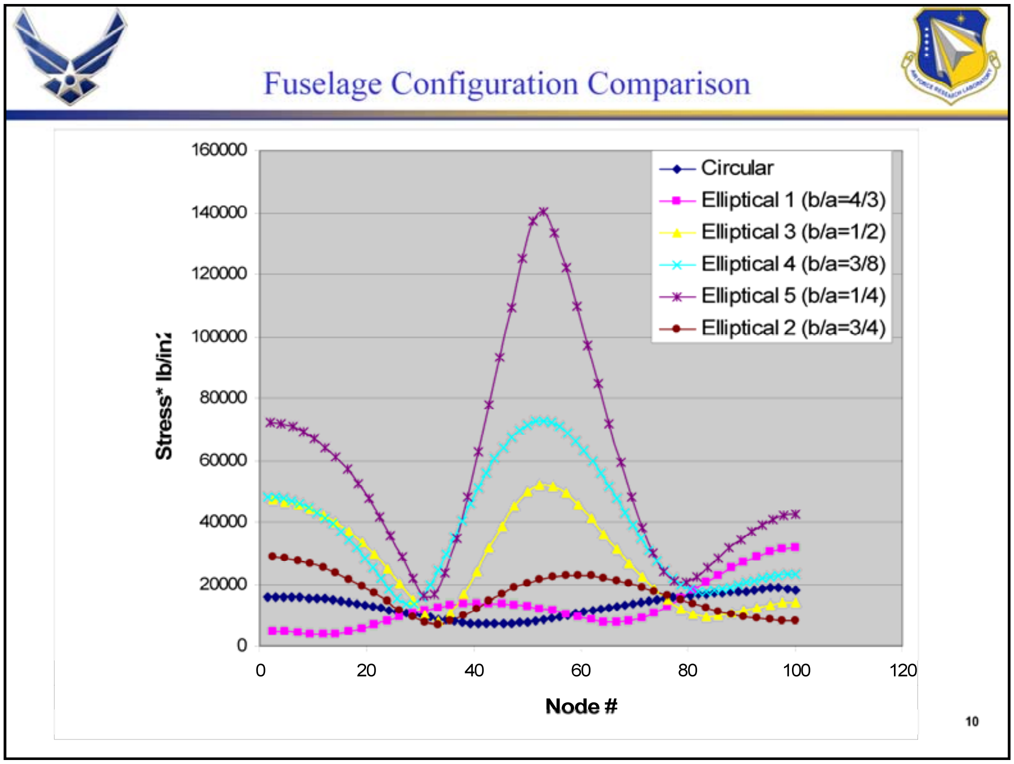
The finite element models generated for this study is shown. The panels are designed to be hat stiffened for the fuselage , and the ring frames are I-beam shaped.



Initial stress results were collected for the six generic fuselage configurations.



Shown are the analysis results for the peak stresses for each configuration. As the ratio of fuselage height over length gets smaller the peak stress rises. The curve can be represented by the shown exponential equation.



Different stress curves are shown for each fuselage configuration as compared to the baseline circular configuration.

Fuselage Structural Trades

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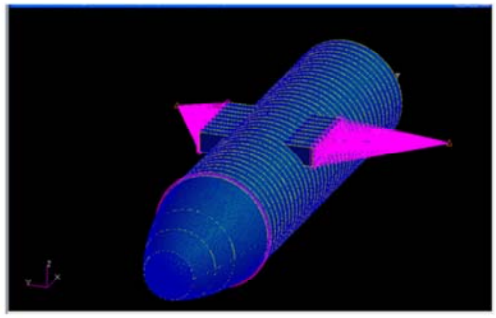
Assumptions

- 3 different fuselage designs: Circular, Elliptical 3/4 & Elliptical 4/3
- All have same volume
- All subjected to same loads:
  - 7 psi Pressure
  - Aerodynamic loads
    - M=0.8 at 36,000 ft
    - Angle of attack = 10 deg.
  - 3 g Inertia
- Loads introduced from tail
- Loads reacted at approximate center of lift for each wing



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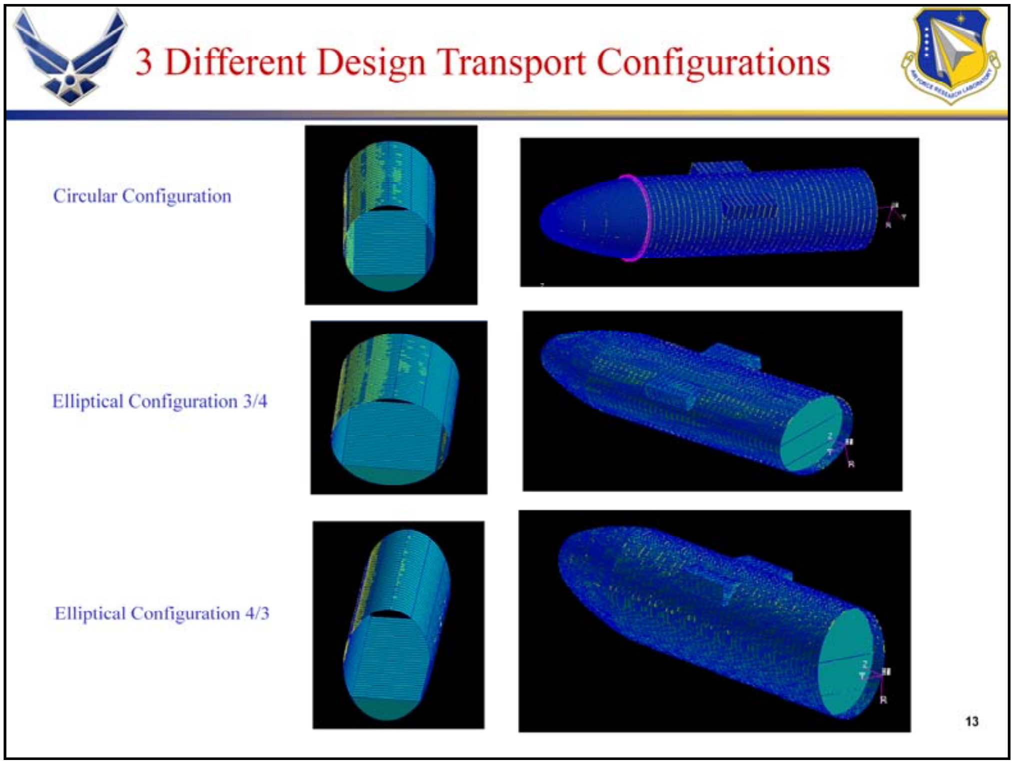
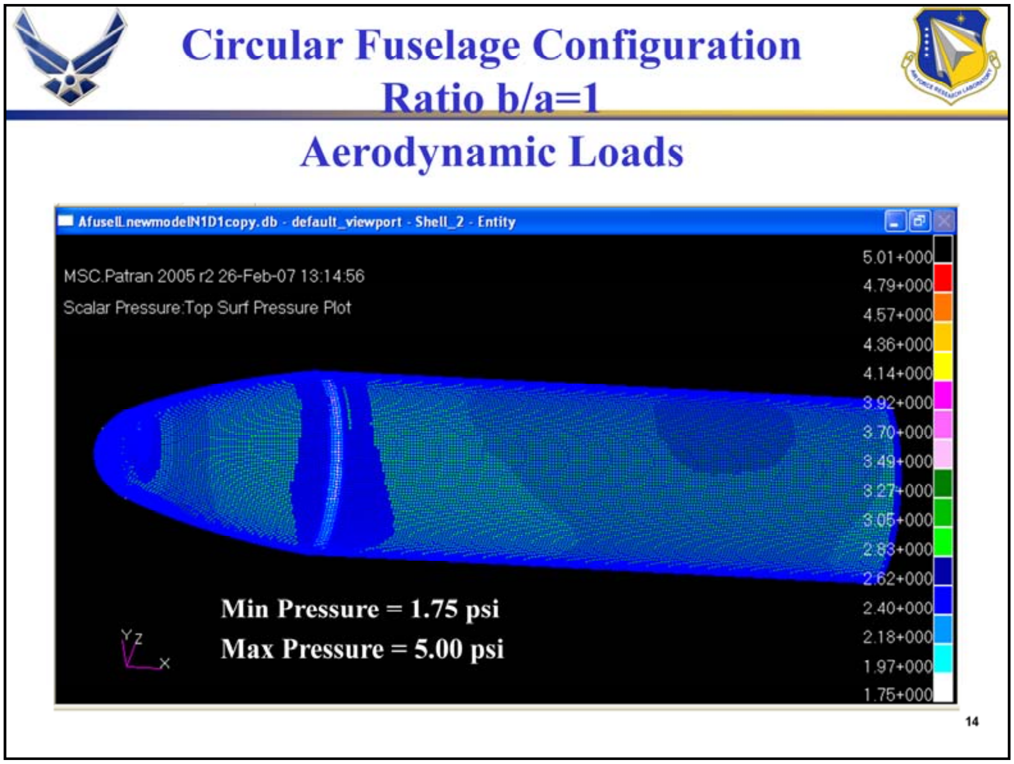
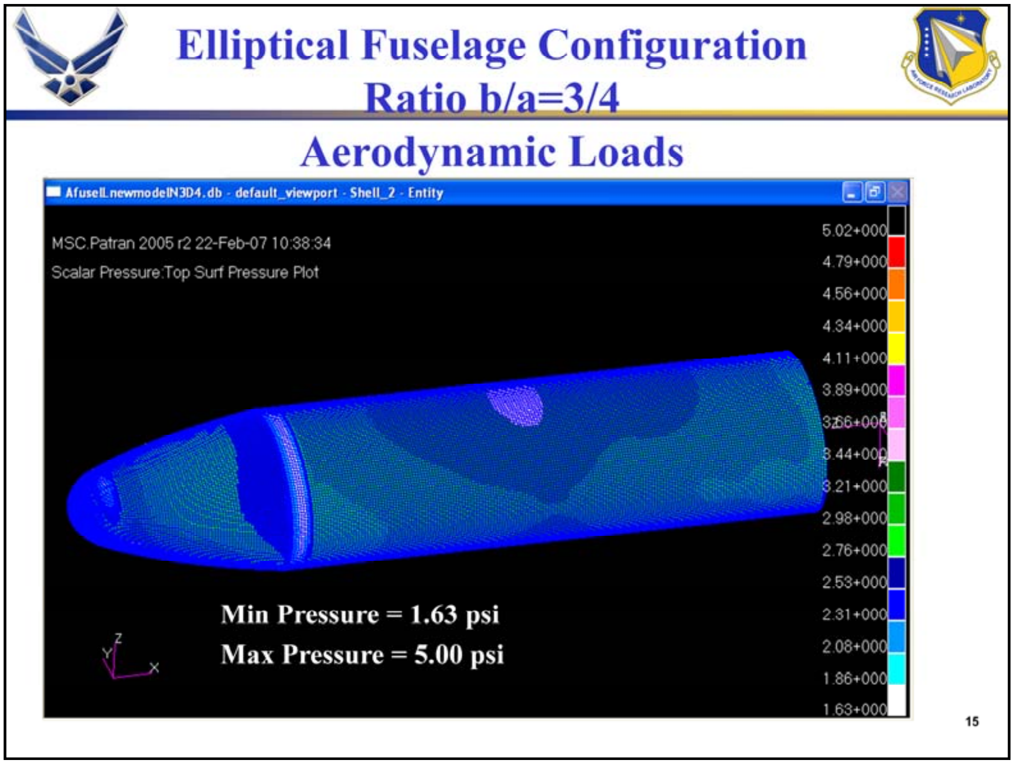
Here are the assumptions that were made for the three different fuselage configurations. Representative flight loadings, internal pressure, aerodynamic loading and gravity were used to calculate stresses.



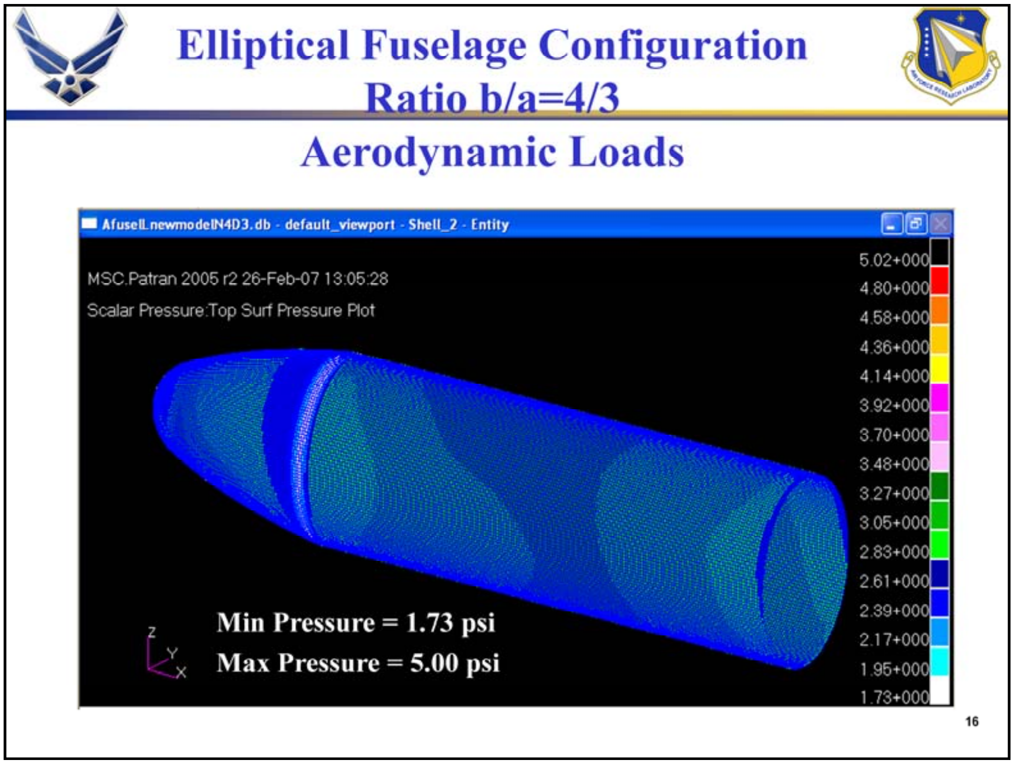
The initial analysis was done on generic configurations. Getting into the more realistic model loading and geometry, a more representative of actual aircraft structure including the cargo floor are shown.



Shown are the aerodynamic loads that were applied to the circular fuselage with a minimum pressure of 1.75 psi and a maximum pressure of 5 psi.



Shown are the aerodynamic loads that were applied to the elliptical fuselage with a minimum pressure of 1.63 psi and a maximum pressure of 5 psi.



Also shown are the aerodynamic loads that were applied to the third elliptical fuselage.

Weight Optimization Nastran into HyperSizer

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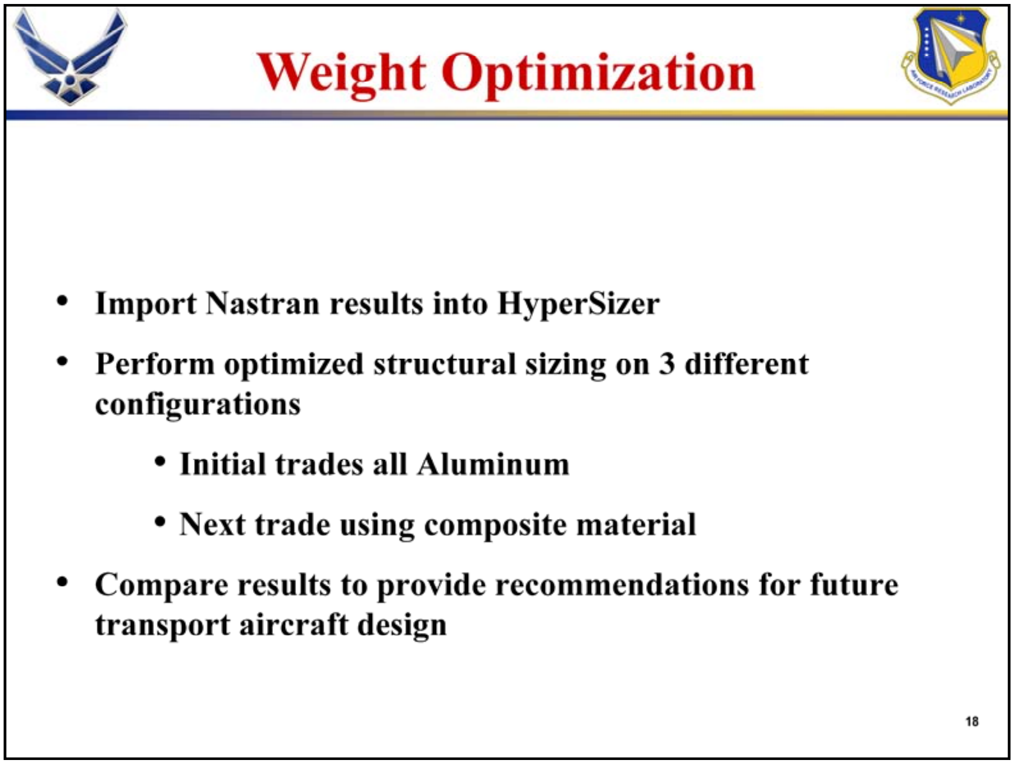
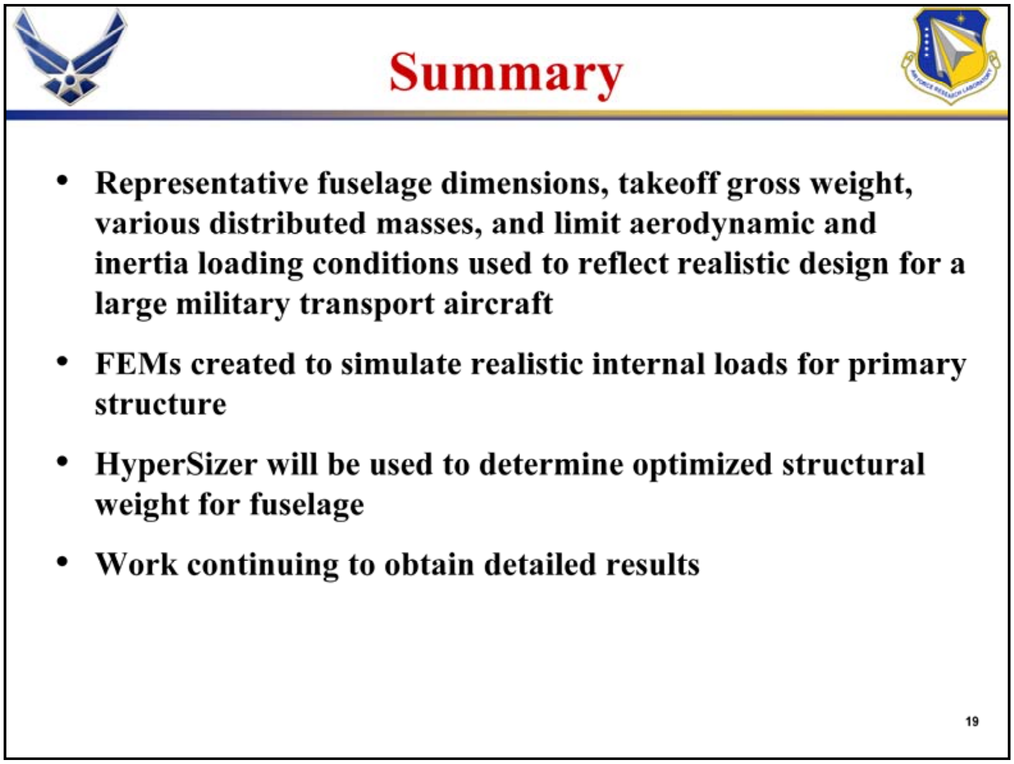


MSC/NASTRAN was used as the loads model, and the entire model will be optimized using HyperSizer. HyperSizer, developed by Collier Research Corporation, is able to optimize in a manner which guarantees structural integrity of the entire model using methods to accurately compute margins of safety (MoS) for all potential failures.



A summary of the effort is shown. The results of this study will be used to influence decisions regarding the shape preferences for potential fuselage design candidates.